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Engineering Analysis and Restoration of Go-kart

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ABSTRACT

This study presents the design, analysis, and fabrication of a lightweight go-kart prototype aimed at achieving optimal performance, safety, and cost effectiveness. The project focuses on key engineering aspects such as chassis design, steering geometry, braking system, and power transmission. A systematic approach was adopted to select suitable materials and components, ensuring structural integrity while minimizing weight. The fabrication process involved precision manufacturing and assembly techniques to meet design specifications. Performance evaluation of the go-kart was conducted based on parameters such as speed, stability, maneuverability, and braking efficiency. The results demonstrate that the developed go-kart meets the desired functional requirements and provides a practical understanding of automotive design principles. This project serves as an effective platform for applying theoretical knowledge to real-world mechanical engineering applications.

Keywords: *Chassis, AISI, Go-kart, Material Selection, External Components, Body Improvement*.

INTRODUCTION

A go-kart project is an essential application of mechanical engineering principles that provides practical exposure to vehicle design, fabrication, and performance analysis. Go-karts are small, lightweight, four-wheeled vehicles typically used for recreational racing and educational purposes. This project focuses on the complete development of a go-kart, including the design of the chassis, steering system, braking system, and power transmission unit. The primary objective is to create a cost-effective, safe, and efficient vehicle while maintaining optimal performance.

Go-kart is a simple four-wheeled, small engine, single Seated racing car. They were initially created in the 1950s, Post-war period by airmen as a way to pass spare time. Art Ingles is generally accepted to be the father of karting. He built the first kart in Southern California in 1956. From then, it is being popular all over America and also in Europe. A Go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks, but are sometimes driven as entertainment or as a hobby by non-professionals.

Karting is commonly perceived as the stepping stone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available. As a free-time activity, it can be performed by almost anybody and permitting licensed racing for anyone from the age of 8 onwards. Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people associate it with young drivers, but adults are also very active in karting.

This project helps students bridge the gap between theoretical knowledge and practical implementation. It enhances skills in problem-solving, teamwork, and engineering analysis. Overall, the go-kart project serves as a foundation for understanding fundamental automotive systems and encourages innovation in vehicle design and manufacturing.

Go-Kart is a great outlet for those interested in racing because of its simplicity, cost and safer way to race. The tracks go-kart is similar to F1 racing track. A go-kart is powered by 125cc engine in most of the countries. In some countries, go-karts can be licensed for use on public roads. Typically, there are some restrictions, e.g. in the European Union a go-kart on the road needs head light (high/low beam), tail lights, a horn, indicators and a maximum of 20 HP.

In a Go-Kart, there are mainly six parts. They are:

i. Chassis
ii. Engine
iii. Steering
iv. Transmission
v. Tyres
vi. Brake

MATERIAL AVAILABILITY

AISI 4130 is a low-alloy chromium-molybdenum steel, widely used in automotive and aerospace structures due to its high strength-to-weight ratio, toughness, and weldability. It is especially popular in go-kart chassis, roll cages, and aircraft frames, where both strength and reduced weight are critical. The addition of chromium and molybdenum improves hardness, fatigue strength, and resistance to wear compared to plain carbon steels. The material used in designing and development of this project is AISI 4130. This steel provides necessary strength. This metal combines both iron and carbon elements along with manganese, sulphur chromium and silicon. Due to its versatile properties it is dominating in the current market. It is so useful that the American iron & steel industry and Society of Automotive Engineers (SAE) outlined numerous grades of steels which are made for specific purposes and denoted by 3 to 5-digit identifiers. 4130 is commonly used alloy steel.

Physical Properties of AISI 4130

4130 steel gets its name from specific rules outlined by SAE & AISI. The first digit i.e. 4 of 4130 alloy indicates the class of steel. The second digit i.e. 1 represents the relative percentage of this alloying element and other important secondary elements present in the material and the remaining last two digits which is 30 represents the carbon concentration. By knowing these rules of 4130 steel, 4XXX & 41XX series (chromium -molybdenum steels) with around 1% molybdenum/chromium by mass with an included 0.30% carbon.

Property	Value (Typical)
Density	7.85 g/cm³
Melting Point	1420 – 1540 °C
Thermal Conductivity	~42 W/m·K
Electrical Resistivity	0.000022 Ω·m
Specific Heat	~0.477 J/g·°C

The chemical breakdown for AISI 4130 steel is given below:

i. 0.28 - 0.33% Carbon
ii. 0.7 - 0.9% Manganese
iii. 0.8 - 1.1% Chromium
iv. 0.15 - 0.25% Molybdenum 5) ≤ 0.04% Sulphur
v. 0.15 - 0.35% Silicon
vi. ≤ 0.035% Phosphorus

Chemical Composition Table

Element	Percentage (%)	Function / Role
Carbon (C)	0.28 – 0.33	Increases strength and hardness
Chromium (Cr)	0.80 – 1.10	Improves corrosion resistance and hardenability
Molybdenum (Mo)	0.15 – 0.25	Enhances toughness and high-temperature strength
Manganese (Mn)	0.40 – 0.60	Improves strength and wear resistance
Silicon (Si)	0.15 – 0.35	Increases strength and elasticity
Phosphorus (P)	≤ 0.035	Impurity (reduces ductility)
Sulfur (S)	≤ 0.040	Improves machinability but reduces strength
Iron (Fe)	Balance	Base metal

Mechanical Properties of AISI 4130

Comparison of materials based on their mechanical properties constitutes an important aspect in the material selection process. Properties like density, tensile strengths, modulus of elasticity, reduction of area and machinability are the major properties that affect the manufacturability and performance of the chassis based on safety and weight reduction. The material with the least density will form the lightest chassis, and vice versa. Yield strength symbolizes the minimum stress at which the deformation of a material becomes plastic. Once the stress values exceeds this yield strength, the deformation caused is permanent. Certain plastics show linear elastic deformation leading to material fracture on reaching the maximum strength.

Hence, it can be understood that a material with higher value of yield strength can resist greater values of working stresses produced. Ultimate tensile strength is the maximum tensile load a material can withstand prior to fracture. It describes the material's resistance to fail or fracture under tensile loads. Bulk modulus is a numerical constant that describes the elastic properties of a solid or fluid when it is subjected to pressure on all sides. When pressure is applied to a material, its volume decreases, but it returns to its original volume when the pressure is removed. It describes a substance's resistance to a change in volume when acted upon by compressive forces on all sides. It is calculated by finding the applied pressure per unit relative deformation. Hence, higher the value of Bulk's modulus, lower the deformation occurring on impact. Poisson's ratio is the ratio of the lateral shrinkage strain to the tensile strain.
AISI 4130 has a density similar to most steels but offers better performance due to alloying elements. Its moderate thermal conductivity helps in heat dissipation, which is useful in high-stress mechanical applications.

Mechanical properties	**Metric**
Modulus of Elasticity	205 MPa
Ultimate tensile strength	670 MPa
Tensile yield strength	435 MPa
Rockwell B Hardness	92
Elongation of Break	25.5%

The elastic modulus is a measure of a material's elasticity, it is common mechanical which is used to show material stiffness. 4130 steel has high modulus of elasticity of 205 MPa which is higher than some strength steels such a 4018 steel. This shows that 4130 steel has high rigidity and does not bend easily and can withstand large stresses and still returns to its original position.
Hardness is the ability of material that describes the response of material to local surface deformation. There are many hardness test scales that depend on standard hardness testing machines. The most common alloy Rockwell indenter machine is used & 4130 steel has a hardness of 92 which is high for steel and shows why 4130 steel is so tough. Mainly hardness indicates increase in stiffness.

Application of 4130 Steel

4130 alloy steel is an exceptionally tough material vital to welding, manufacturing, cutting, grinding and other high stress applications in industry. 4130 steel's great heat treatment characteristics impart a high toughness and, combined with its great machinability, workability and therefore this steel is widely useful.
AISI 4130 is widely used in:

i. Go-kart chassis and racing frames
ii. Aircraft structural components
iii. Bicycle frames
iv. Roll cages in motorsport
v. Pressure vessels and pipelines

CHASSIS DESIGN

The chassis has been designed by taking factors like dimensional limits (width, height, length, and weight), operational restrictions, regulatory issues, contractual requirements, financial constraints and human ergonomics as a priority.
Alloys like 4130 and 4140 possess. But 4130 is a popular steel in race car industry but is not easily available in India. Therefore, the material that the team chose to use is AISI 1018.
The benefit of using the AISI 1018 is that it can be easily wielded than the 4130 chromyl. The AISI 1018 has the same Modulus of Elasticity (E) and density as the 4130, so using it does not affect the weight or stiffness in member with same geometry.

Performance of the kart

The first characteristic that comes to mind when the word performance is used with respect to automobiles is acceleration. It is a well-known fact that for an applied force, the acceleration generated is inversely proportional to the mass of a body. Thus, the material used for the second heaviest component of the go-kart, the chassis, has a great potential to provide performance increments.

Economic effectiveness

When a material is being chosen for a particular component in a car, cost acts as a major factor in this decision. For student competitions, it is necessary to stay within the range of the budget allotted to a particular team and not overspend. The cost is usually divided into three sectors: the cost of raw materials, the manufacturing value added, and the cost of designing and validating the product. For this paper, selection of material for the chassis is the aim taking these 3 sectors into consideration. Composite Materials are inarguably more expensive than alloy steels and cast irons currently in use. Because the cost of lighter metals may be higher, decisions to use them must be justified by improved performance.

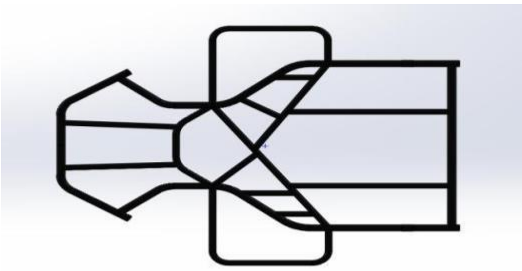

Figure-1: Geometric Model of Chassis

VIEW OF THE GO-KART

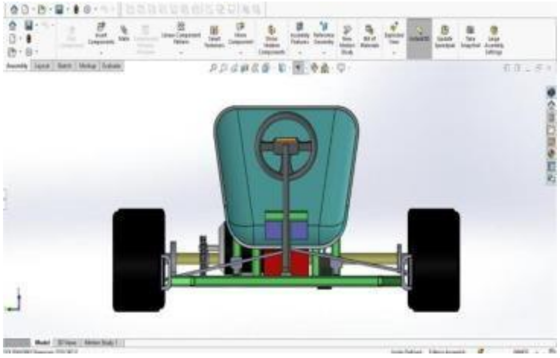

Figure-2: Front view

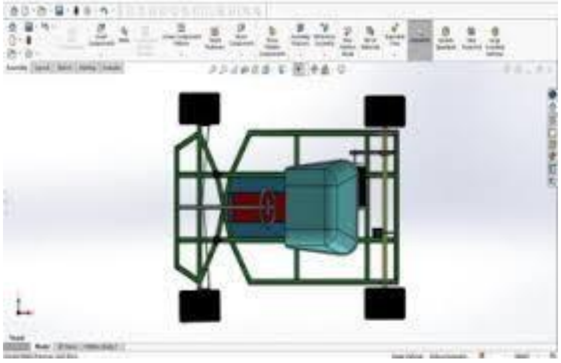

Figure-3: Top view

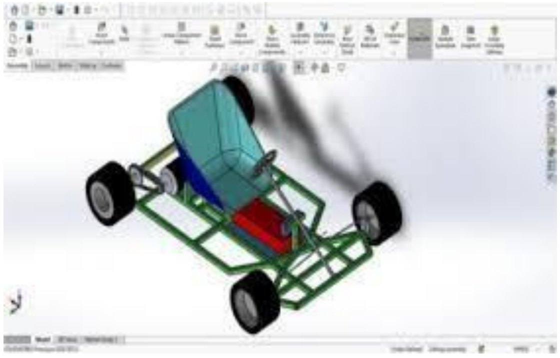

Figure-4: Isometric view

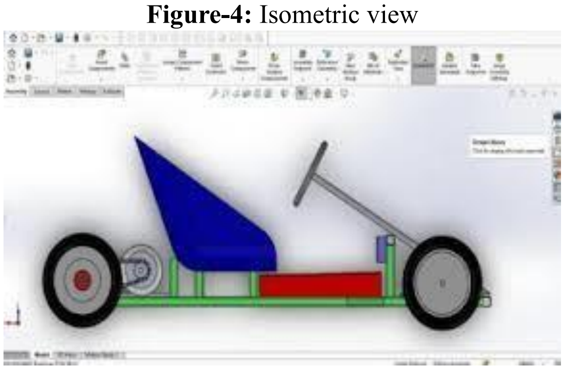

Figure-5: Side view

PERFORMANCE EVALUATION OF REBUILT GO-KART

This gives the detail comprehensive testing protocols employed to quantify improvements in acceleration, braking efficiency, cornering dynamics, and overall structural rigidity following the integration of external components. Key performance indicators such as lap times, maximum G-forces endured, and sustained velocity on varied terrain will be meticulously recorded and analysed to provide empirical evidence of the efficiency of the modifications.

BODY OF GO-KART

Objective

The purpose of the go-kart body and composite structure is to provide protection to the driver, support the overall structure, and enhance vehicle performance. It helps reduce the weight of the kart while maintaining strength and rigidity, improves aerodynamics, and ensures durability against impact and environmental conditions. Additionally, it contributes to better handling, stability, and efficiency during operation.

Seat

The seat in a go-kart is a critical component designed to ensure driver comfort, control, and safety. Typically, the seat is mounted at a reclined angle of about 30° to 45° from the vertical, allowing the driver to maintain a low centre of gravity. This angled position improves stability, reduces the risk of tipping, and enhances cornering performance by keeping the driver's weight evenly distributed across the chassis. It is rigidly fixed to the chassis rather than adjustable, ensuring consistent weight distribution and structural integrity. The seat must securely hold the driver in place, minimizing unwanted movement during acceleration, braking, and turning. Proper mounting also helps in effective transfer of forces between the driver and the kart. The seat is designed to match the natural posture of the human body. It supports the spine, especially the lower back, and provides lateral support to the torso to reduce fatigue during driving. The contours of the seat help maintain proper alignment of the arms and legs, allowing easy access to the steering wheel and pedals. Good ergonomic design ensures that the driver can operate the kart comfortably for longer durations while maintaining full control and responsiveness.

Engine and Powertrain Upgrades

Engine and powertrain upgrades in a go-kart are aimed at improving performance, efficiency, and reliability. These upgrades focus on increasing power output, enhancing torque delivery, and ensuring smooth transmission of power to the wheels. For the engine, common upgrades include increasing engine displacement, improving air intake and exhaust systems, and optimizing the air-fuel mixture. High-performance carburettor, performance air filters, and tuned exhaust systems help the engine breathe better, resulting in higher power and quicker acceleration. In some cases, engine tuning or replacing the stock engine with a more powerful one is also considered. In the powertrain, upgrades are made to improve power transmission and durability. This includes using high-quality chains, sprockets, and bearings to reduce friction and wear. Adjusting gear ratios by changing sprocket sizes can significantly affect acceleration and top speed. A larger rear sprocket improves acceleration, while a smaller one increases top speed.

Breaking and Steering system improvement

One major improvement is upgrading from basic mechanical brakes to hydraulic disc brakes, which provide better braking force and smoother operation. Using high-quality brake discs with better heat dissipation helps prevent brake fade during continuous use. Ventilated or larger diameter discs can further improve cooling and performance. Another important aspect is the use of high-friction brake pads, which increase stopping power and reduce braking distance. Proper alignment and positioning of the brake calliper ensure even pressure distribution on the disc, leading to consistent braking. Improving the braking system also involves optimizing.

The goal is to achieve smooth, accurate steering with minimal effort while maintaining stability at high speeds and during cornering. One key improvement is optimizing the steering geometry, including proper alignment of camber, caster, and toe angles. Correct geometry ensures better tire contact with the ground, improving grip and reducing tire wear. Increasing caster angle slightly can improve straight-line stability and steering return.

Upgrading steering components such as tie rods, kingpins, and bearings with high-quality, low-friction materials helps reduce play and improves responsiveness. A well-designed steering column with proper support bearings ensures smooth rotation and minimizes vibration. Ergonomically, the steering wheel position should be adjusted for comfortable reach and better control, allowing the driver to maintain a firm grip without fatigue. Proper placement also ensures quick reaction during sudden maneuvers.

CONCLUSION

This research successfully demonstrated the feasibility and benefits of rebuilding and modifying a standard go-kart through the integration of external components and advanced materials, yielding substantial improvements in structural integrity, powertrain efficiency, and dynamic performance. These enhancements underscore the potential for systematic engineering approaches to optimize recreational and competitive karting platforms, aligning with principles of sustainable engineering through component reuse and targeted material application. Future research could explore the long-term durability and cost-effectiveness of these modifications under various operational stresses, alongside investigating the integration of intelligent systems for real-time performance optimization.

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